

MANTASWEEP SMART POOL CLEANER

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Abstract

Mantasweep can realize the combination of physical cleaning and chemical cleaning. It draws inspiration from the body structure of the filter-feeding animal devil ray, and realizes the filtration and cleaning of sedimentation attachments on the pool wall through the entrainment negative pressure structure; real-time monitoring and display of basic water quality data such as pH value and urea, and multi-purpose screw feed structure Chlorine solution is injected by point diffusion to ensure that the water quality meets the standard; the exterior is wrapped with flexible materials, allowing it to work in the presence of swimmers; it also has its own base station, which can automatically recharge or replace the filter element. MantaSweep is likely to become the standard configuration of public swimming pools in the future.

Key Words : Swimming pool cleaning; bionics; Visualization; New ecology of swimming pool

1 Introduction

1.1 Background and significance

There are currently 28000 swimming pool related enterprises in China. In the past decade, the registration volume of related enterprises has gradually increased, with an annual registration volume of over 5000 in the past three years. Commercial swimming pools account for over 90% of the total in China.

Although the swimming and fitness industry has broad prospects for development, there are also some challenges. The requirements of the state and relevant departments for hygiene management have been increasing year by year, and the demand for water quality in swimming pools has only increased but not decreased. So we need to make a better cleaning tool.

2 Design Research

2.1 Market Competition

According to the survey, in the analysis of the penetration rate of the global pool cleaning market, manual cleaning accounted for 45%, suction equipment accounted for 28%, pressure equipment accounted for 8%, and swimming pool cleaning robots accounted for 19%. According to market research reports, the global pool cleaning industry market was worth approximately \$2.6 billion in 2019. It is expected

that by 2026, the global pool cleaning robot market will reach \$3.533 billion, achieving steady growth.

The main competitors in the pool cleaning industry market include companies such as Hayward Industries, Pentair, Zodiac Pool Systems, and Maytronics. These companies have a significant market share, but there are still many small and medium-sized enterprises in the market that are constantly growing.

At present, the intelligence level of swimming pool cleaning robots is gradually improving. Traditional cleaning tools still rely on the original filtration system of the swimming pool, which is cumbersome and labor-intensive to operate. The new experience of cleaning robots is equipped with an independent filtering system that hardly requires human intervention, but there are still issues such as cable entanglement and short battery life.

2.2 User research

We conducted on-site research on 16 swimming pools, interviewed 79 stakeholders, and conducted two questionnaire surveys. We received a total of 239 questionnaires and 189 valid ones. We learned that the difficulty in cleaning a swimming pool lies in the dirt under the cushion layer, which needs to be submerged in the water to absorb; The difficulty of detection lies in the need to rely on experience to replenish chlorine into the swimming pool every day. The cleaners' expectations for pool cleaning tools mainly include optimizing manual fishing methods, simplifying operating procedures, and controlling the amount of chemical reagents used.

3 Smart Swimming Pool - Multifunctional Robots

3.1 Functional Requirements

When designing an underwater intelligent cleaning robot, the following requirements need to be considered:

1. The robot system runs smoothly and can operate stably in underwater environments, avoiding shaking or flipping during the cleaning process.
2. It can achieve obstacle avoidance and precise positioning in different underwater environments, avoiding robots from colliding with obstacles or getting lost.
3. The image acquisition module needs to be able to capture clear images in an underwater environment and perform high-precision recognition and analysis.
4. The robot needs to be able to automatically plan the cleaning route, select the optimal path according to the cleaning needs, and also need to be able to adjust the cleaning route in real-time.
5. Users can see the working status and cleaning route of the robot in real-time, and can remotely control the robot.

3.2 Mechanical Structure Design

Device composition, DSSERVO waterproof steering gear, Brushless DC motor, Skywalker Brushless Electric Adjustment, Sonar, Battery, Wireless communication module, Battery voltage detection, DuPont Line, Dual axis motor.

3.2.1 Appearance design

The robot adopts the shape of devil fish, and its body presents a streamline design. Its surface is covered with wear-resistant materials, which can resist chemicals and high temperatures in the swimming pool environment. The tail of the robot

is designed with tail fins and rudder wings, which can control the direction and speed of the robot, making it more flexible to move in the swimming pool.

Independently designed waterproof shell and reasonably designed mechanical mechanism. A well-designed mechanical mechanism can ensure stable operation of the machine in water and enable it to complete various tasks underwater. At the same time, the waterproof shell can ensure that the machine is not affected by moisture and corrosion in water, improving the service life of the machine.

3.2.2 Control System

The control system of the robot consists of a central processing unit, sensors, and actuators, which can control the robot's movement, cleaning, and chemical dosing. The control system can receive data obtained from sensors and control robots for cleaning and chemical dosing operations based on preset algorithms and control strategies. At the same time, the control system can also monitor the robot's power and operating status, and make adjustments and optimizations as needed.

The main control chip selects stm32f427iihx as the MCU. STM32F427IIHX is a high-performance, low-power, 32-bit ARM CortexM4 processor microcontroller unit. Its main frequency is 180MHz, with a large amount of memory, interfaces, and peripherals, suitable for handling complex computing and communication tasks. Choosing this chip can ensure the processing power and operational stability of the machine.

3.2.3 Drive system

The robot adopts a drive system consisting of two electric wheels and a rear rudder to achieve its movement and steering in the swimming pool. The speed and

direction of the two electric wheels are controlled by the control system, allowing the robot to move forward, backward, left, right, and other directions. The rudder wings at the tail can change the direction of the robot, making it more flexible to move in the swimming pool.

Double shaft motor drive is selected to improve the mechanical efficiency, movement stability, dynamic performance and control accuracy of the machine.

The combination of brushless DC motor and brushless electric regulator achieves efficient, high-power, and high-speed control of the machine's forward and backward propellers.

Choose DSSERVO waterproof servo, model ds3230, to achieve 360 degree no dead angle water spraying. DSSERVO waterproof servo ds3230 is a high-performance waterproof servo with high accuracy and speed. It can rotate 360 degrees to achieve no dead angle water spraying. Choosing this servo can improve the control accuracy and stability of the machine.

3.2.4 Cleaning System

The cleaning device of the robot includes brushes, vacuum cleaners, and filters, which are located in the cleaning module at the bottom of the robot. The brush is driven by the drive system and can remove dirt from the bottom of the pool. A vacuum cleaner can suck dirt from the bottom of the swimming pool and the water surface into the filter inside the robot for filtration. The filter is located at the rear of the cleaning module and can be disassembled and replaced at any time.

3.2.5 Execution System

Tail two turbines	Advance and adjust posture while preventing waste from entering Pressure can be increased during dead corner cleaning Increase the diffusion rate when spreading the agent
Intermediate turbine	During normal cleaning, it acts as a suction device to absorb impurities in the water. Control the lifting and lowering of the robot When cleaning the wall and dead corners at the bottom or wall of the pool, a negative pressure is formed using turbine thrust, which can be stabilized on the wall with suction cups, making it convenient for robots to carry out cleaning work. (Combining negative pressure adsorption with thrust adsorption).
Walking track	The track motion mechanism can achieve steering by changing the driving speed of the driving wheels, making it easier to control. When climbing walls, the contact area of the track is large, the adsorption force is stronger, and it can adapt to the curvature changes of the circular fish pond surface, ensuring stable travel.
Cut off the red part Connecting rod brush disc	The connecting rod structure achieves income and extension, used to wipe dead corners and other areas that are difficult for traditional swimming pool robots to clean
Pharmacy storage drawer	Used for storing chemicals, with multiple drawers permanently used for storing chemical agents such as sterilization, disinfection, water quality clarification, pH regulation, and polymerization sedimentation.
Screw feed placement	Using a screw to perform feed motion to disperse the agent
Suction drum	The multi tooth suction drum can extremely effectively remove flocculent and fibrous substances from water, and combined with polymer settling agents and the suction generated by the drum's rotation, it can achieve the cleaning of large areas of impurities

Comb shaped filter plate	Combined with the drum, it can further improve the absorption of impurities in water and effectively salvage garbage on the water surface
Battery+ Swimming pool fixed point electric pile	To solve the problem of cables being prone to entanglement and knotting, and the movement distance depending on the length of the cable, a battery is used for power supply, increasing the activity area and flexibility of the robot. For a large swimming pool, the duration of each cleaning is a burden for the robot. To solve the problem of low battery capacity and insufficient endurance performance of the robot, an electromagnetic wireless charging station is set at the necessary position on the cleaning path to replenish point energy.

3.2.6 Communication system

Select ESP8266 to achieve communication and issue instructions. SP8266 is a low-power, high-performance Wi Fi chip that can be used to achieve communication between machines and other devices. By using ESP8266, commands can be issued remotely to control the operation and behavior of the machine.

3.3 Software System Design

3.3.1 Attitude calculation part

Gyroscope data is calculated based on quaternion, including data from accelerometers, magnetometers, and gyroscopes, and PI controllers are used for calibra-

tion. The main idea is to use the information provided by accelerometers and magnetometers to estimate the direction of gravity and magnetic field, and use them as the desired attitude direction. Then, using the attitude change rate information provided by the gyroscope, combined with the correction of the PI controller, the attitude is updated based on the quaternion equation.

3.3.2 Motion control

By sending information to ESP8266 through the punctual atom atomic cloud, ESP8266 then communicates with the main controller through serial port to control the servo and motor to achieve chemical cleaning and physical cleaning respectively.

4 Prospects of Works

4.1 Product application prediction

According to market information forecast, Mantasweep Smart Pool Cleaner if can be formally put into production and listed, will be purchased and used by pools of all sizes across the country. Its use will greatly save manpower and material resources, solve the problem of time-consuming and laborious pool cleaning at the present stage, and can effectively improve the water quality of the pool, improve the user experience, and truly change life with design.